



# FATALITIES IN DIVERS USING REBREATHERS

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## INTRODUCTION

- ❖ The number of diving deaths involving rebreathers appears to be increasing worldwide.
- ❖ We conducted a preliminary investigation of differences in fatalities for divers using rebreathers and open-circuit breathing apparatus.

## METHODS

- ❖ Root Cause Analysis (1) was applied to DAN diving fatality surveillance data.
  - The goal was to identify Trigger events, Harmful Actions and Disabling Injuries, where possible.
- ❖ Information about non-US/Canada residents was difficult to obtain and limited.

	Rebreather	Open-Circuit (1)
Cases (years)	78 (1998-2006)	947 (1992-2003)
Age (y; mean±SD, range)	45±11 (24-72)	43±13 (12-79)
Male (%)	97	81
US/Canada Cases (%)	40	100

## RESULTS

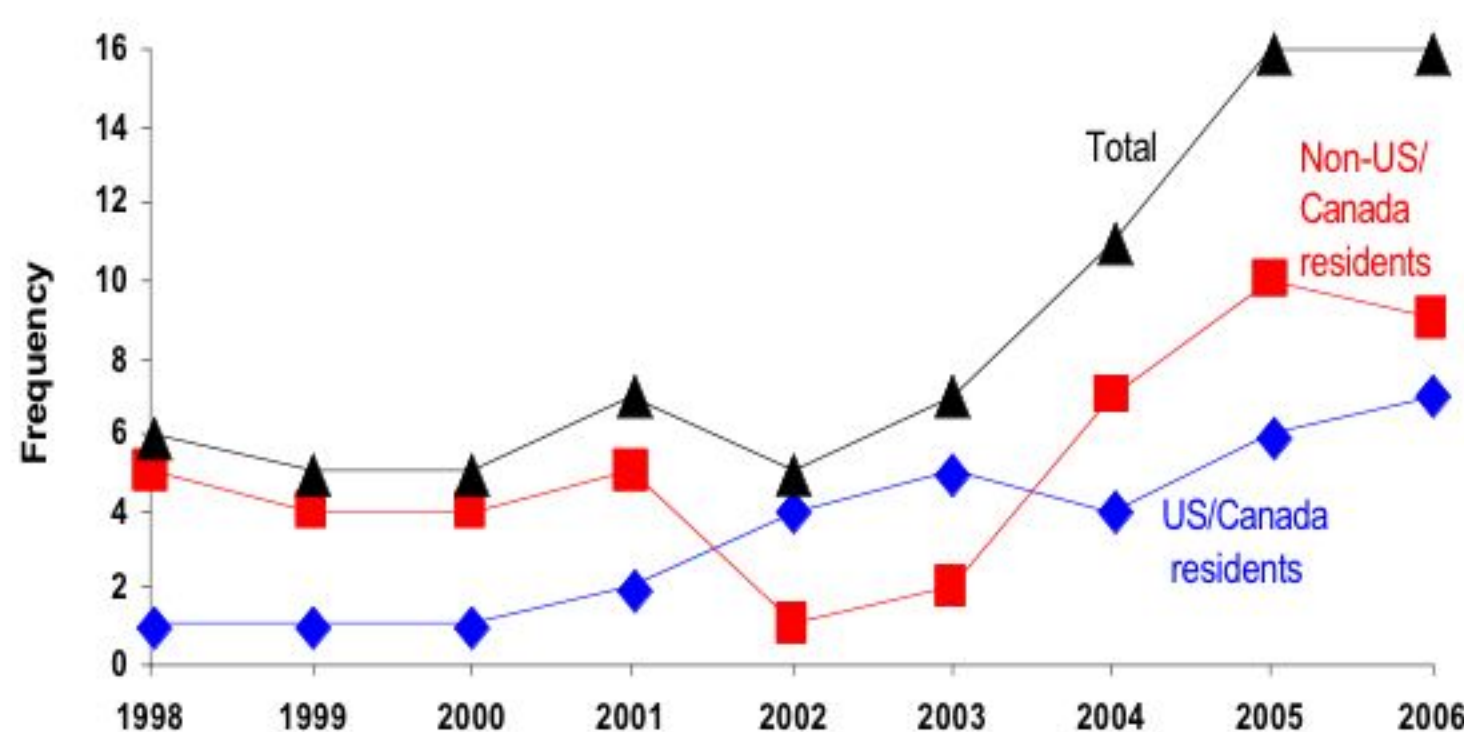


Figure 1. Rebreather fatalities identified worldwide 1998-2006 increased after 2002.

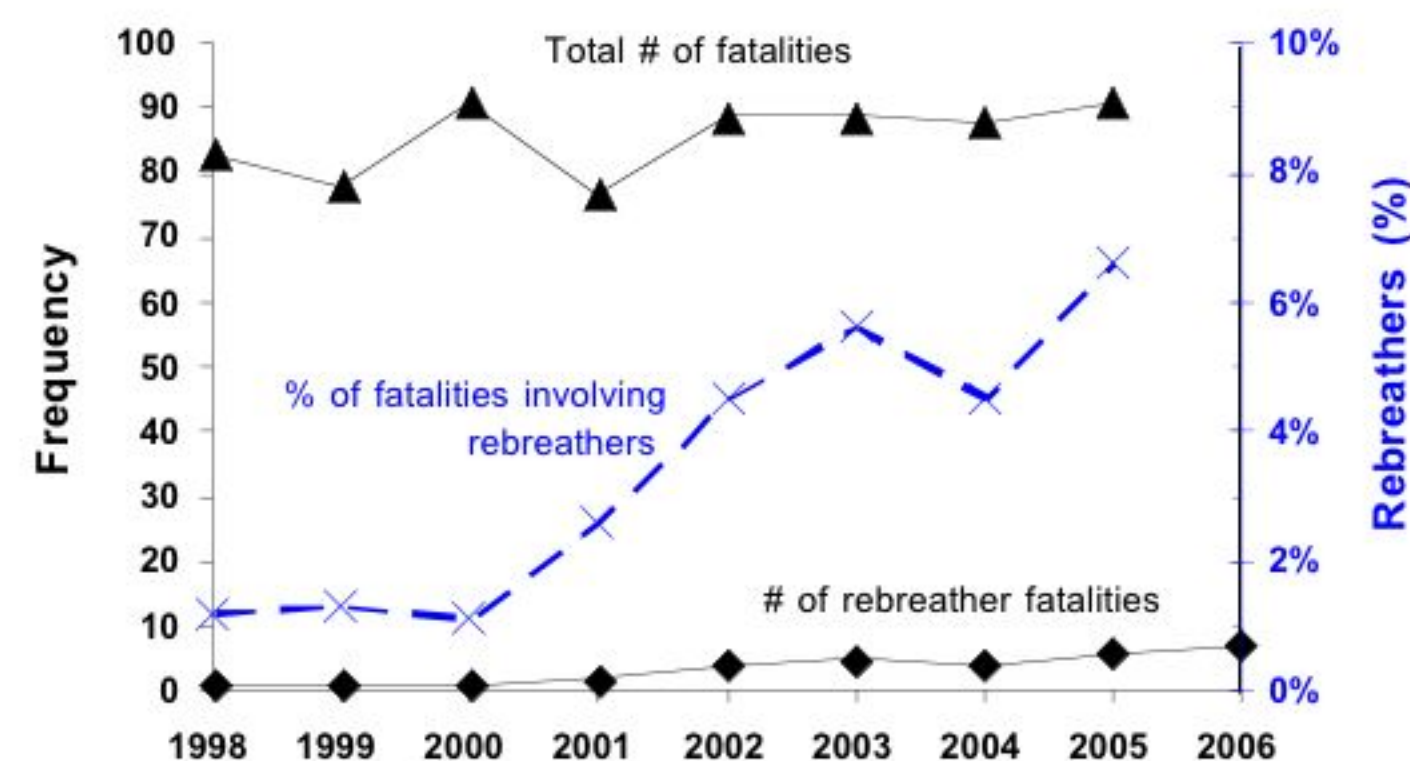


Figure 2. Rebreather fatalities represent a growing share of total diving fatalities in US/Canada since 2000.

- ❖ Equipment & buoyancy problems more common Triggers with rebreathers than open-circuit (Fig. 3).
  - 11 equipment procedure problems (e.g., gas or power off, incorrect set-up, gas leak)
  - 3 equipment malfunctions (e.g., flooded display, O<sub>2</sub> supply failure)
  - 4 buoyancy problems specific to rebreathers (i.e., surfaced, left mouthpiece open, lost buoyancy, sank)
  - 3 general buoyancy problems (drysuit blow-up, lift bag entanglement)

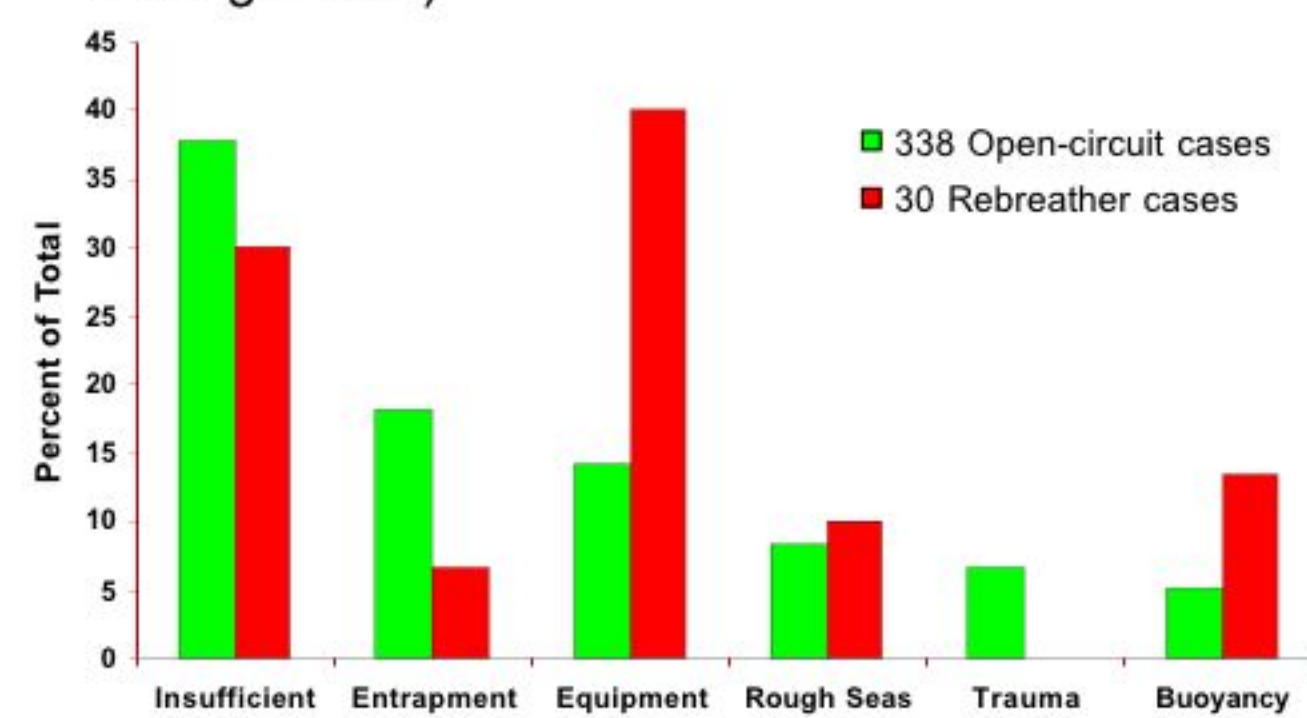


Figure 3. Triggers.

- ❖ Hypoxia/Seizures and equipment trouble were more common Harmful Actions with rebreathers (Fig. 4).

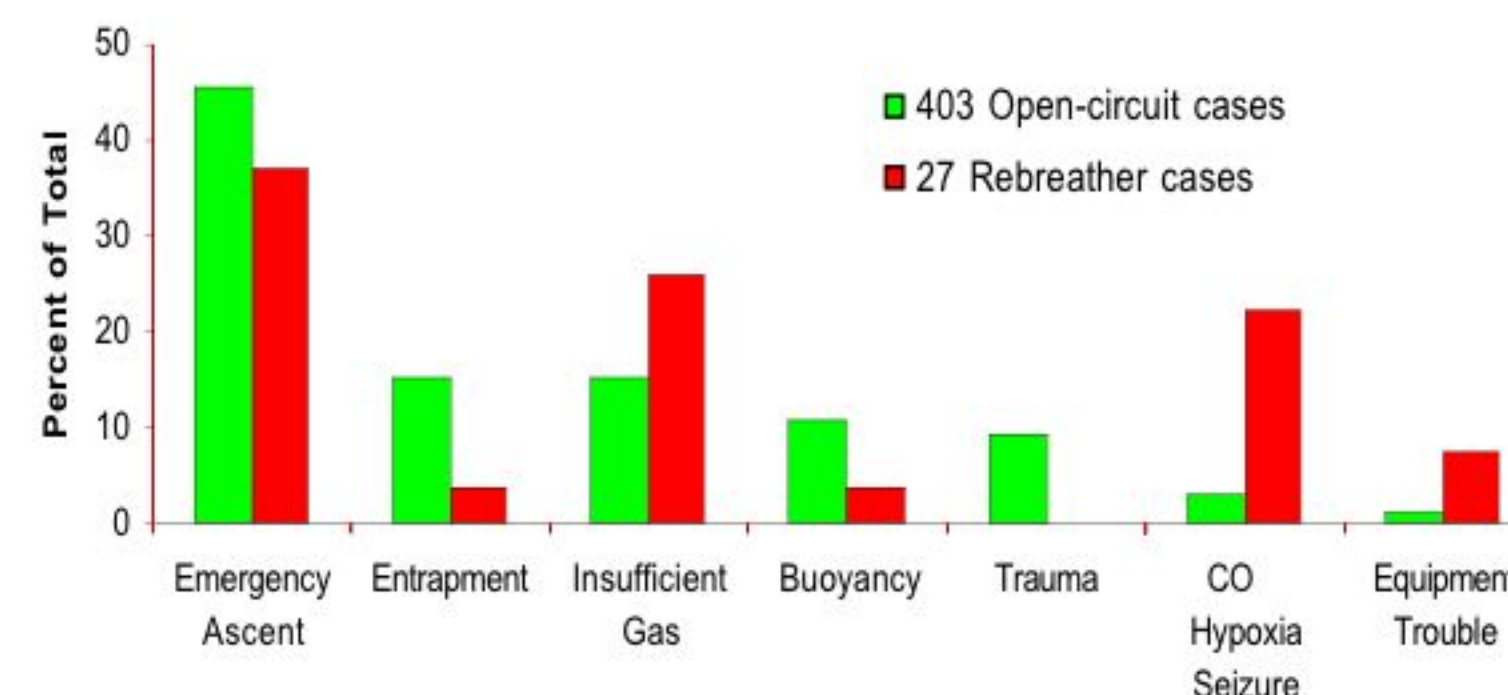


Figure 4. Harmful Actions

- ❖ Drowning and cardiac incidents were less common Disabling Injuries with rebreathers than open-circuit (Fig. 5).
- ❖ Inappropriate gas was the major Disabling Injury with rebreathers.
  - 13 rebreather divers lost consciousness early in the dive, suggesting hypoxia
  - 5 rebreather divers were observed to have seizures, suggesting oxygen toxicity

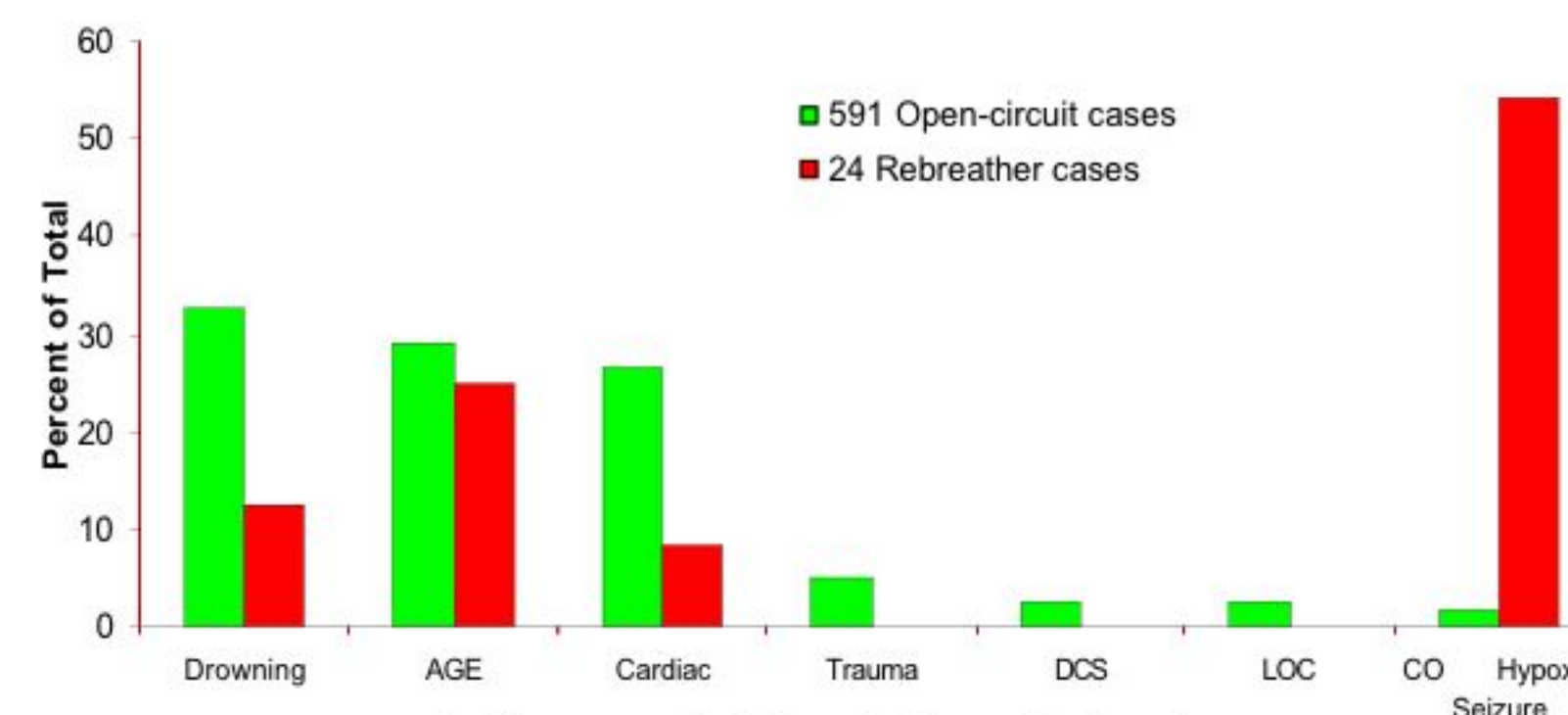


Figure 5. Disabling Injuries

## DISCUSSION

- ❖ The rise in rebreather fatalities is probably associated with their increasing popularity.
- ❖ According to the Pareto principle (1), the greatest reduction in rebreather fatalities might be achieved by emphasizing training and safety guidelines related to equipment trouble and hypoxia/seizures.
  - Equipment procedural problems (diver error) seemed more common than equipment malfunction.
- ❖ Investigation of non-US/Canadian cases was difficult, but perhaps this can be overcome by cooperation among International DAN affiliates.
- ❖ Equipment recovered after a fatality should enter a formal chain of custody.
  - Qualifications for equipment inspection & inspectors remain to be defined.

## LIMITATIONS

- ❖ The number of rebreather fatalities missed by the DAN surveillance system is unknown.
- ❖ Information about rebreather fatalities is more limited than about open-circuit fatalities

## CONCLUSIONS

- ❖ Focusing on the most frequent problem areas can have the greatest impact in reducing fatalities.
- ❖ Inferences concerning rebreathers are preliminary.

## REFERENCES

1. Denoble PJ. Application of the Pareto principle to recreational diving deaths. 2007 UHMS Meeting.